

SPECIFICATION

WATER ACTIVATED RELEASE TRIGGERING MECHANISM

BACKGROUND OF THE INVENTION

[0001] The field of the invention is an automatic release mechanism, and the invention relates more particularly to a water activated automatic release mechanism for a parachute harness.

[0002] U.S. Patent No. 5,857,247 issued January 12, 1999, for "Buckle System for Manual or Automatic Release of Crew Member Harness from Parachute" and assigned to the assignee of the present application, discloses a buckle system having many of the features of the present invention. The '247 patent is incorporated herein by reference for background purposes.

[0003] Combat aircraft often operate over water, and due to the role of such aircraft, crew members may experience a need to parachute from the aircraft. Such need may result from hostile fire in combat, from an accident, or due to equipment failure. The crew members may further experience injury prior to exiting the aircraft, during the exiting, or after the exiting. In some cases, a crew member may land in water in an unconscious or disabled condition. If the crew member should land in water, and is unable to release their parachute, the added weight and/or drag may pull the crew member below the water surface, and may result in further injury or drowning.

[0004] To prevent such further injury or drowning, known parachute harnesses include an automatic release mechanism. Such release mechanism includes at least two critical requirements.

1 First, that the mechanism has a high probability of correctly releasing the parachute if the crew
2 member becomes immersed in water. Second, a near zero probability of false release. Generally, the
3 crew member will be able to release the parachute, and therefore a failure of the automatic release
4 mechanism to perform a correct release is generally not a critical event. Alternatively, a false release
5 may be a fatal event.

6 **[0005]** The '247 patent teaches such release mechanism integrated internally into a buckle of the
7 parachute harness. Although the release mechanism of the '247 patent provides the needed automatic
8 release functionality, the release mechanism is not easily removed from the buckle for service, battery
9 replacement, or to upgrade to a new release mechanism. Further, a new buckle system has been
10 developed which requires a new automatic release mechanism. What is needed is an automatic
11 release mechanism for the new buckle, which new automatic release mechanism may easily be
12 removed for service, battery replacement, or to upgrade with a new release mechanism. Due to the
13 extreme cost of a false release, there is also a need for false release events to have the lowest possible
14 probability, while maintaining a reasonable probability of correct release.

15 **BRIEF SUMMARY OF THE INVENTION**

16 **[0006]** The present invention addresses the above and other needs by providing a water activated
17 release triggering mechanism which is removably held to an exterior surface of a buckle housing and
18 includes at least two probes, and at least two batteries distributed between independent paths, for
19 firing a squib. The batteries are selected such that a single battery can not cause the squib to fire.
20 Thus, the distribution of batteries between independent paths, combined with the power level of each

1 battery, precludes false firing from a single short with the housing of the release mechanism. The
2 batteries may be soldered into the associated circuit, and may be easily tested through the probes.
3 The triggering mechanism is designed to be impervious to Electro Magnetic Interference (EMI) and
4 to preclude false fire in the presence of 20,000 volts of Electro Static Discharge (ESD). The release
5 mechanism may further be designed so that immersion in fresh water, as in the case of exposure to
6 rain, will not cause the squib to fire. The triggering mechanism may be easily removed for servicing,
7 replacement, or for upgrading, and may be designed to allow the batteries to be easily replaced at a
8 depot, or by return to the manufacturer.

9 **[0007]** In accordance with one aspect of the invention, there is provided a water activated release
10 mechanism comprising a first probe exposed to the environment, a second probe exposed to the
11 environment, at least one first battery having a first positive terminal and a first negative terminal, the
12 first positive terminal electronically connected to a first node and the first negative terminal
13 electrically connected to the first probe, at least one second battery having a second positive terminal
14 and a second negative terminal, the second positive terminal electronically connected to the second
15 probe and the second negative terminal electrically connected to the second node, and a squib
16 electrically connected between the first node and the second node. The at least one first battery
17 preferably comprises two three-volt batteries and the at least one second battery preferably comprises
18 two three-volt batteries. The batteries are selected so that the combined output of all of the batteries
19 is required to fire the squib. The batteries are preferably long life batteries, preferable small size, and
20 preferably tolerant to low temperatures, and more preferably lithium batteries and most preferably
21 part number CR1616. The at least one first battery and the at least one second battery may be

1 electrically connected through the first probe and the second probe (i.e., by joint immersion of the
2 first probe and the second probe in salt water) to produce a positive voltage at the first node. The
3 squib is preferably a one amp one watt squib and preferably provides a minimum force of
4 approximately 100 lbs and a stroke of approximately 0.25 inches, and more preferably a part number
5 P1590N actuator manufactured by Eagle Picher in Phoenix, Arizona. The squib may be embedded
6 in a heat sink to inhibit false fire due to low power long term magnetically induced currents, and
7 preferably the squib is electrically connected with a switch, the squib and switch being serially
8 electrically connected between the first node and the second node. The probes may be any
9 conductive material and preferably comprise gold cups. The probes are preferably located on
10 opposite sides of the device housing and preferably approximately two to four inches apart.
11 Alternatively, a single probe may electrically cooperate with the mechanism housing, buckle housing,
12 or other suitable conductor.

13 **[0008]** The mechanism may further include a diode electrically connected between the first node
14 and the second node, a cathode terminal of the diode electrically connected to the first node, an anode
15 terminal of the diode electrically connected to the second node, a third node electrically connected
16 between the anode terminal and the second node, a second resistor electrically connected between
17 the third node and the second node, and a lead electrically connecting the third node to a control gate
18 of the switch. The switch is preferably adapted to remain open until the voltage on the first node is
19 at least the breakdown voltage of the diode, at which event current flows through the diode to the
20 third node and through the lead to close the switch. The diode is preferably a zener diode and more
21 preferably a part number MA8091-H manufactured by Motorola. The second resistor is preferably

1 selected based on the SCR gate current, and more preferably at least approximately a 10,000 ohm
2 resister. The switch is preferably a Silicon Controlled Rectifier (SCR), and more preferably a part
3 number MCR8DSM manufactured by Motorola.

4 **[0009]** The mechanism may further include a capacitance C electrically connected between the first
5 node and the second node and a resistance R1 electrically connected between the first node and the
6 second node. The capacitance C preferable comprised at least approximately 2.7 m Farad
7 capacitance, and more preferably six approximately 0.45 m Farad capacitors, wherein the capacitance
8 may be selected to deliver between 550,000 and 5,000,000 ergs of energy, and preferably, the
9 capacitance C is selected to match the requirements of the squib. The resistance R1 is preferably
10 comprises a 150-ohm thermistor having a negative temperature coefficient, in series with a fixed 350
11 resister. The resistance R1 may be selected to cooperate with the required conductivity across the
12 water probes to establish a maximum charging voltage across the capacitance C

13 **[0010]** It is a further feature of the present invention to provide a water activated release mechanism
14 comprising a first probe exposed to the environment, a second probe exposed to the environment, at
15 least one battery electronically connected between the first probe and a first node, or the second probe
16 and a second node, wherein the at least one battery is electrically connected to produce a positive
17 voltage at the first node, a first resister electrically connected between the first and the second node,
18 a capacitance electrically connected between the first node and the second node, a squib and a switch
19 serially electrically connected between the first node and the second node, a diode having an anode
20 terminal and a cathode terminal, the cathode terminal electrically connected to the first node, a third
21 node electrically connected between the anode terminal and the second node, a second resister

1 electrically connected between the third node and the second node, and a lead electrically connected
2 between the third node and a control gate of the switch.

3 **[0011]** It is an additional feature of the invention to provide a method for activating a release
4 mechanism, the method comprising steps of closing a circuit between a first probe and a second probe,
5 creating a positive voltage at a first node from a first battery electrically connected between the first
6 probe and the first node, and from a second battery electrically connected between a second node and
7 the second probe, charging a capacitor electrically connected between the first node and the second
8 node, exceeding a breakdown voltage of a diode having a cathode terminal electrically connected to
9 the first node, and an anode terminal electrically connected to a control gate of a normally open switch,
10 wherein the switch and a squib are serially electrically connected between the first node and the second
11 node, closing the switch, and firing the squib.

12 **BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS**

13 **[0012]** The above and other aspects, features and advantages of the present invention will be more
14 apparent from the following more particular description thereof, presented in conjunction with the
15 following drawings wherein:

16 **[0013]** Figure 1 is a buckle with a release triggering mechanism attached;

17 **[0014]** Figure 2 is a top view of the release triggering mechanism;

18 **[0015]** Figure 3 is one embodiment of a circuit included in a release triggering mechanism;

19 **[0016]** Figure 4 is another embodiment of a circuit included in a release triggering mechanism;

20 **[0017]** Figure 5 is a preferred embodiment of a circuit included in a release triggering mechanism;

1 [0018] Figure 6 includes parallel plots of resistance and voltage values during operation of a release
2 triggering mechanism; and

3 [0019] Figure 7 is a flow chart of a method of operation of a release triggering mechanism.

4 [0020] Corresponding reference characters indicate corresponding components throughout the
5 several views of the drawings.

6 DETAILED DESCRIPTION OF THE INVENTION

7 [0021] The following description is of the best mode presently contemplated for carrying out the
8 invention. This description is not to be taken in a limiting sense, but is made merely for the purpose
9 of describing one or more preferred embodiments of the invention. The scope of the invention should
10 be determined with reference to the claims.

11 [0022] A harness buckle mechanism 10 including a buckle housing 12, a strap holder 14, and a water
12 activated release triggering mechanism 16 is shown in Figure 1. The triggering mechanism 16 is
13 removably held to an exterior surface of a buckle housing, and preferably held to the surface which
14 rests against a human body when the harness is in use, thus cushioning the triggering mechanism 16
15 against impacts. The triggering mechanism 16 is attached to the buckle housing 12 so as not to affect
16 the load path of the parachute harness. The triggering mechanism 16 includes a housing which is
17 preferably solid and preferably made from aluminum. The triggering mechanism 16 may be sealed
18 to protect the elements with the triggering mechanism 16 from the environment.

19 [0023] A top view of the triggering mechanism 16 is shown in Figure 2. A mechanism window 18
20 allows an arm, level, or other mechanical member of a buckle mechanism 10 to extend into the

1 triggering mechanism 16 to mechanically cooperate with the triggering mechanism 16. In other
2 embodiments, an arm or other mechanical element may protrude from the triggering mechanism 16
3 to provide cooperation with a buckle mechanism, or the triggering mechanism may be integrated into
4 a buckle mechanism, and these other embodiments are intended to come within the scope of the
5 present invention. The triggering mechanism 16 further includes four screw passages 20 to facilitate
6 removal and replacement of the triggering mechanism 16. The triggering mechanism 16 may be
7 attached to the buckle housing 12 by various other attachment methods, for example more or less than
8 four screws, cooperation of features of the triggering mechanism 16 and features of the buckle housing
9 12, pop rivets, or the like, and a triggering mechanism 16 attached by any other method is intended
10 to come within the scope of the present invention.

11 **[0024]** The triggering mechanism 16 is an electro-mechanical device which includes a circuit for
12 detecting the immersion of the device in water, and preferably immersion of the device in sea water.
13 A first example of a circuit for use in the triggering mechanism 16 is shown in Figure 3. The circuit
14 includes a first probe P1, and a second probe P2, with water conductivity path 32 between the probes
15 P1 and P2. The probes are preferably gold cups, and are preferably on the exterior of the triggering
16 mechanism 16 approximately two to four inches apart and on opposite sides of the trigger mechanism
17 16. In other embodiments, the probes may be recessed in the triggering mechanism, or the probes
18 may be distally located from the triggering mechanism 16 and electrically connected to the triggering
19 mechanism by probe leads, and such embodiments are intended to come within the scope of the
20 present invention. A first battery B1 is electrically connected between the probe P1 and a squib 26,
21 and a second battery B2 is independently electrically connected between the probe P2 and the squib

1 26. A piston or actuator 28 resides in the squib 26, and when the squib 26 fires, the piston 28 is
2 pushed against a member 30 which initiates the release of the buckle. By placing the batteries in
3 independent paths, a single short between a path or a probe and the triggering mechanism 16 housing
4 can only provide half the required energy to the squib 26, thus preventing a false fire.

5 **[0025]** A second example of a circuit for use in the triggering mechanism 16 is shown in Figure 4.

6 In many cases, the triggering mechanism 16 must operate in a highly electromagnetically active
7 environment without false firing. In such environment, even a short wire may act as an antenna and
8 produce current flow within a circuit. In order to preclude false fires in such environments, a one watt
9 one amp squib is preferably used. Additionally, the circuit may be designed to be impervious to
10 Electro Magnetic Interference (EMI) and to preclude false fire in the presence of 20,000 volts of
11 Electro Static Discharge (ESD).

12 **[0026]** The second circuit includes at least one battery B1 to create a positive voltage at a first node
13 N1. The battery B1 is preferable electrically connected between the first probe P1 and the node N1,
14 and may alternatively be electrically connected between a second node N2 and the second probe P2.
15 Preferably, the battery comprises two independent batteries, with a first battery electrically connected
16 between the probe P1 and the node N1, and a second battery electrically connected between the probe
17 P2 and the node N2, and more preferably two independent batteries serially electrically connected
18 between the probe P1 and the node N1, and two independent batteries serially electrically connected
19 between the probe P2 and the node N2, which batteries are connected to contribute to a positive
20 voltage at the node N1. A capacitor C is electrically connected between the node N1 and node N2.
21 A first resistor R1 is connected between the nodes N1 and N2 in parallel with the capacitor C, to

1 calibrate the conductivity . The squib 26 and a switch M are serially electrically connected between
2 the nodes N1 and N2, and a first diode D1, a third node N3, and a second resistor R2 are serially
3 electrically connected between the nodes N1 and N2, wherein the node N3 is electrically connected
4 between the diode D1 and node N2, and the resistor R2 is connected between the node N3 and the
5 node N2. The cathode terminal of the diode D1 is electrically connected to the node N1, and the
6 anode terminal of the diode D1 is electrically connected to the node N3. A lead L electrically connects
7 the node N3 to a control gate on the switch M.

8 **[0027]** When the probes P1 and P2 are immersed in sea water, the resistance between the probes
9 P1 and P2 drops and current flows into the capacitor C. Initially, the diode D1 prevents current flow
10 to the node N3, and the switch M remains open, thus preventing current from flowing through the
11 squib 26. When the voltage across the capacitor C (i.e., the voltage between the nodes N1 and N2)
12 reaches the breakdown voltage of the diode D1, current flows through the diode D1 to the node N3,
13 and through lead L to the switch M. The switch M closes, and current flows through the squib 26,
14 causing the squib 26 to fire. The piston 28 is pushed against the member 30 which initiates the release
15 of the buckle.

16 **[0028]** In other embodiments, an analog or digital circuit may monitor the voltage V_c across the
17 capacitance C, and compare V_c to a threshold voltage V_t . If V_c reaches or exceeds V_t , a signal may
18 be sent to the switch M to close the circuit through the squib 26. Such other embodiments are
19 intended to come within the scope of the present invention.

20 **[0029]** A preferred embodiment of a circuit of the release mechanism is shown in Figure 5. Two
21 batteries B2 are serially electrically connected between the node N2 and the probe P2. Two additional

batteries B1 are serially electrically connected between the node N1 and the probe P1. The batteries B1 and B2 are preferably long life cells, and more preferably lithium batteries, and most preferably CR1616 batteries. Two resistors R3 and R4 are serially electrically connected between the nodes N1 and N2. The resistor R3 is preferably a thermistor, and more preferably a 150-ohm thermistor having a negative temperature coefficient, to allow the circuit to adjust to different operating temperatures. The resistor R4 is preferably a 350 ohm resistor. A capacitance C is also electrically connected between the nodes N1 and N2, which capacitance C is preferably an approximately 2.7 m Farad capacitance, and more preferably six approximately 0.45 m Farad capacitors, and most preferably part number TPSE477K01R0050 made by Commonwealth Sprague located in North Adams, Massachusetts.

[0030] A second diode D2, third node N3, and a second resistor R2 are serially electrically connected between the nodes N1 and N2, wherein the node N3 is electrically connected between the diode D2 and node N2, and the resistor R2 is connected between the node N3 and the node N2. The cathode terminal of the diode D2 is electrically connected to the node N1, and the anode terminal of the diode D2 is electrically connected to the node N3. The diode D2 is preferably a zener diode, and more preferably (specs for zener diode?) And most preferably part number MA8091-H manufactured by (name, city, state).

[0031] The squib 26 (Figures 3 and 4) is represented by an equivalent resistance R5 which is serially electrically connected with a Semiconductor Controlled Rectifier (SCR) between the nodes N1 and N2. The SCR is preferably a part number MCR8DSM manufactured by Motorola. A lead L

1 electrically connects the node N3 to a control gate on the SCR. A circuit thus configured provides
2 substantially all the advantages of the circuits described in Figures 3 and 4.

3 **[0032]** The operation of the circuit of Figure 5 may be more easily ascertained from reviewing
4 Figure 6. The top plot shows the resistance R_p across the probes P1 and P2. Prior to immersion in
5 sea water, the resistance R_p is very high, and effectively zero current flows between the probes P1 and
6 P2. At time T1, the probes are immersed in sea water, the resistance R_p drops to approximately 100
7 ohms for 10,000 micromhos conductivity, and current flows between the probes P1 and P2, creating
8 a positive voltage at node N1. The middle plot shows the voltage V_c across the capacitor C, which
9 is also the voltage between the nodes N1 and N2. The voltage V_c is initially approximately zero volts.
10 At time T1, the capacitor begins to charge, and the voltage V_c begins to rise. Initially, the diode D2
11 prevents current from flowing to the node N3. At time T2, the voltage V_c reaches the breakdown
12 voltage of the diode D2 and current flows to the node N3, to the control gate of the SCR, and the
13 SCR closes the circuit through the squib 26 (or equivalent resistance R5). Starting at T2, voltage V_s
14 flows through the squib 26, and the resulting energy 34 builds in the squib 26. At time T3 the energy
15 raises the temperature sufficiently to fire the squib 26.

16 **[0033]** A method according to the present invention is shown in Figure 7. The circuit between the
17 probes P1 and P2 is closed at step 40. The resulting current flow creates a positive voltage at node
18 N1 at step 42. The voltage at node N1 causes the capacitor C to charge at step 44. When the voltage
19 V_c across the capacitor C reaches the breakdown voltage of the diode D2 at step 46, current flows
20 to the node N3, and to the switch, causing the switch to close at step 50. Current then flows through
21 the squib 26, and the squib 26 fires at step 52.

1 **[0034]** The circuits described above, may alternatively be expressed based on the relationship of the
2 circuit elements. Beginning with water actuation, the conductivity (resistance) of the water that the
3 unit is intended to function in is the starting point for the design. Very fresh water, such as from a
4 household tap, has 100 to 1000 micro-mhos conductivity. Sea water, on the other hand, has values
5 of 10,000 to 40,000 micro-mhos conductivity. These conductivity values equate to water resistance
6 of 10,000 to 1000 ohms for fresh water and 100 to 25 ohms for sea water. This resistance appears
7 between the water probes when the unit is immersed in water. Referring to Figure 3 above, these
8 conductivity values apply to path 32. There is thus formed a series circuit B1/R1/path 32 with voltage
9 divided between R1 and 32. Thus, the value for R1 may be selected based on the voltage is required
10 to fire the selected squib 26.

11 **[0035]** For example, the squib 26 may require 5 volts to fire. If the voltage drop across the switch
12 (M), when it is turned on, is .5 volts, a safety margin is desirable to guarantee that the squib 26 will
13 fire when required. A fifty percent safety margin is preferred for the squib 26 firing voltage. Adding
14 these voltages (5.5 volts + 2.75 volt safety margin) results in 8.25 volts. The capacitor C is the source
15 of the firing voltage, and as a result, the switch M preferably triggers when there is 8.25 volts across
16 the capacitor C. A zener diode may be selected that triggers the switch M at approximately 8.25 volts.
17 When the voltage on the capacitor C exceeds 8.25 volts, the switch M turns on and provides 8.25 volts
18 across the squib 26. The value of the resistor R1 may be calculated such that the voltage across
19 resistor R1 in the R1/path 32/B1 series circuit is greater than the required 8.25 volts. The voltage
20 across the resistor R1 is the voltage that the capacitor C will charge toward.

1 **[0036]** For example, if the voltage B1 is 20 volts, the water is 10,000 micro-mhos, and the resistance
2 of path 32 is 100 ohms, a preferred resistance R1 is approximately 300 ohms. The result is 15 volts
3 across resistor R1. When immersed in water, the capacitor C will begin to charge toward 15 volts.
4 When the capacitor C reaches 8.25 volts, the switch M turns on (opens) and the capacitor C
5 discharges through the squib 26 causing the squib 26 to fire.

6 **[0037]** Alternatively, if the resistance R1 is 100 ohms and B1 remains 20 volts, the capacitor C
7 charges toward 10 volts. As a result of the lower charging voltage, the capacitor C will take longer
8 to charge to 8.25 volts. Further, if the water conductivity changes, the resistance of path 32 changes.
9 If the water resistance changes to 3,333 micro-mhos (300 ohms), and the resistance R remains 100
10 ohms, the result is 5 volts across the resistor R1, and the capacitor C will charge toward 5 volts
11 maximum. In this instance, even if the capacitor C is fully charged (i.e., to 5 volts) there is not enough
12 voltage to fire the squib 26. Thus, the circuit may be designed to fire the squib when immersed water
13 having the desired conductivity, or to obtain a desired delay time to firing the squib 26, and a circuit
14 having the basic architecture described above, and including circuit components selected according
15 to these constraints is intended to come within the scope of the present invention.

16 **[0038]** While throughout the above description, the use of batteries as a power source had been
17 described, other power sources may be substituted, and a mechanism using another power source is
18 intended to come within the scope of the present invention.

19 **[0039]** While the invention herein disclosed has been described by means of specific embodiments
20 and applications thereof, numerous modifications and variations could be made thereto by those skilled
21 in the art without departing from the scope of the invention set forth in the claims.